US010662836B2

(12) **United States Patent**
Mitambo et al.

(10) **Patent No.: US 10,662,836 B2**
(45) **Date of Patent: May 26, 2020**

(54) **INTEGRATED HEATER AND PRESSURE SENSOR FOR PCV SYSTEM**

(71) Applicants: **Pierre Mitambo**, West Bloomfield, MI (US); **Colton Wyatt**, Lake Orion, MI (US)

(72) Inventors: **Pierre Mitambo**, West Bloomfield, MI (US); **Colton Wyatt**, Lake Orion, MI (US)

(73) Assignee: **FCA US LLC**, Auburn Hills, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/709,587**

(22) Filed: **Sep. 20, 2017**

(65) **Prior Publication Data**

US 2019/0085742 A1 Mar. 21, 2019

(51) **Int. Cl.**
F02M 51/06 (2006.01)
F01M 13/00 (2006.01)

(52) **U.S. Cl.**
CPC ***F01M 13/00*** (2013.01); *F01M 2013/0038* (2013.01); *F01M 2250/00* (2013.01)

(58) **Field of Classification Search**
CPC F01M 13/00; F01M 2013/0038; F01M 2250/00
USPC 123/572–574
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,686,952	A	8/1987	Zeigler et al.	
6,062,206	A	5/2000	Nelson et al.	
7,775,198	B2	8/2010	Shieh	
8,087,403	B2	1/2012	Asanuma et al.	
8,695,339	B2	4/2014	Spix	
2001/0047801	A1 *	12/2001	Baeuerle	F01M 11/10 123/574
2006/0144376	A1	7/2006	Gschwind et al.	
2006/0236989	A1	10/2006	Callahan	
2013/0013171	A1 *	1/2013	Ghafari	F02M 25/06 701/104
2014/0076249	A1	3/2014	Rchinger et al.	
2015/0275718	A1 *	10/2015	Jessberger	F02M 25/06 123/574
2016/0097354	A1 *	4/2016	Martus	F02M 35/10222 123/572

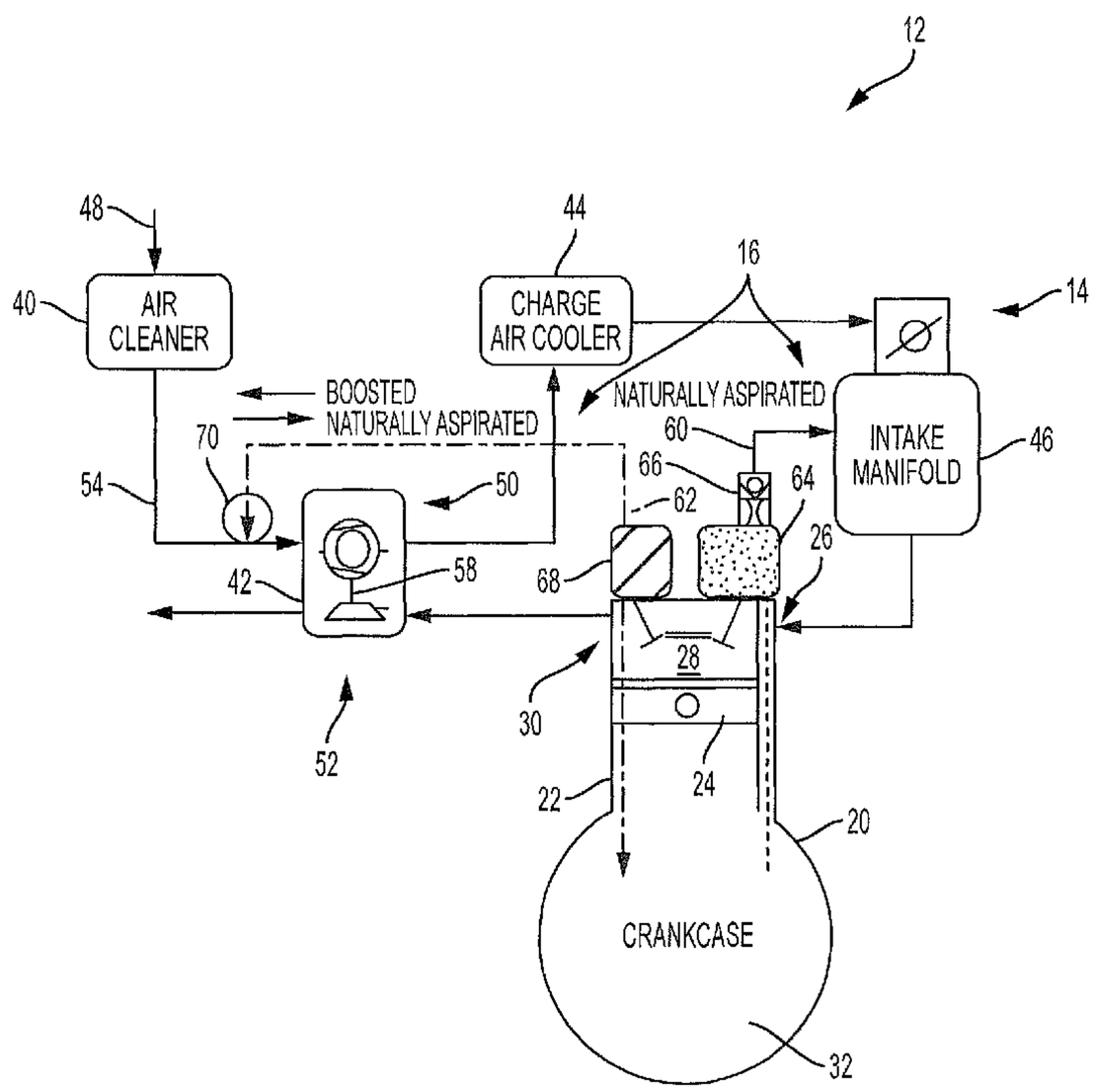
* cited by examiner

Primary Examiner — Marguerite McMahon
(74) *Attorney, Agent, or Firm* — Ralph E. Smith

(57) **ABSTRACT**

An integrated heater and pressure sensor assembly for a positive crankcase ventilation (PCV) system for a vehicle internal combustion engine includes a heater assembly configured to fluidly couple a PCV/makeup air (MUA) line and a vehicle air induction system line, the heater assembly configured to heat fluid passing into and out of the PCV/MUA line, and a pressure sensor assembly integrated directly into the heater assembly, the pressure sensor assembly configured to sense pressure pulsations in the PCV/MUA line.

19 Claims, 4 Drawing Sheets



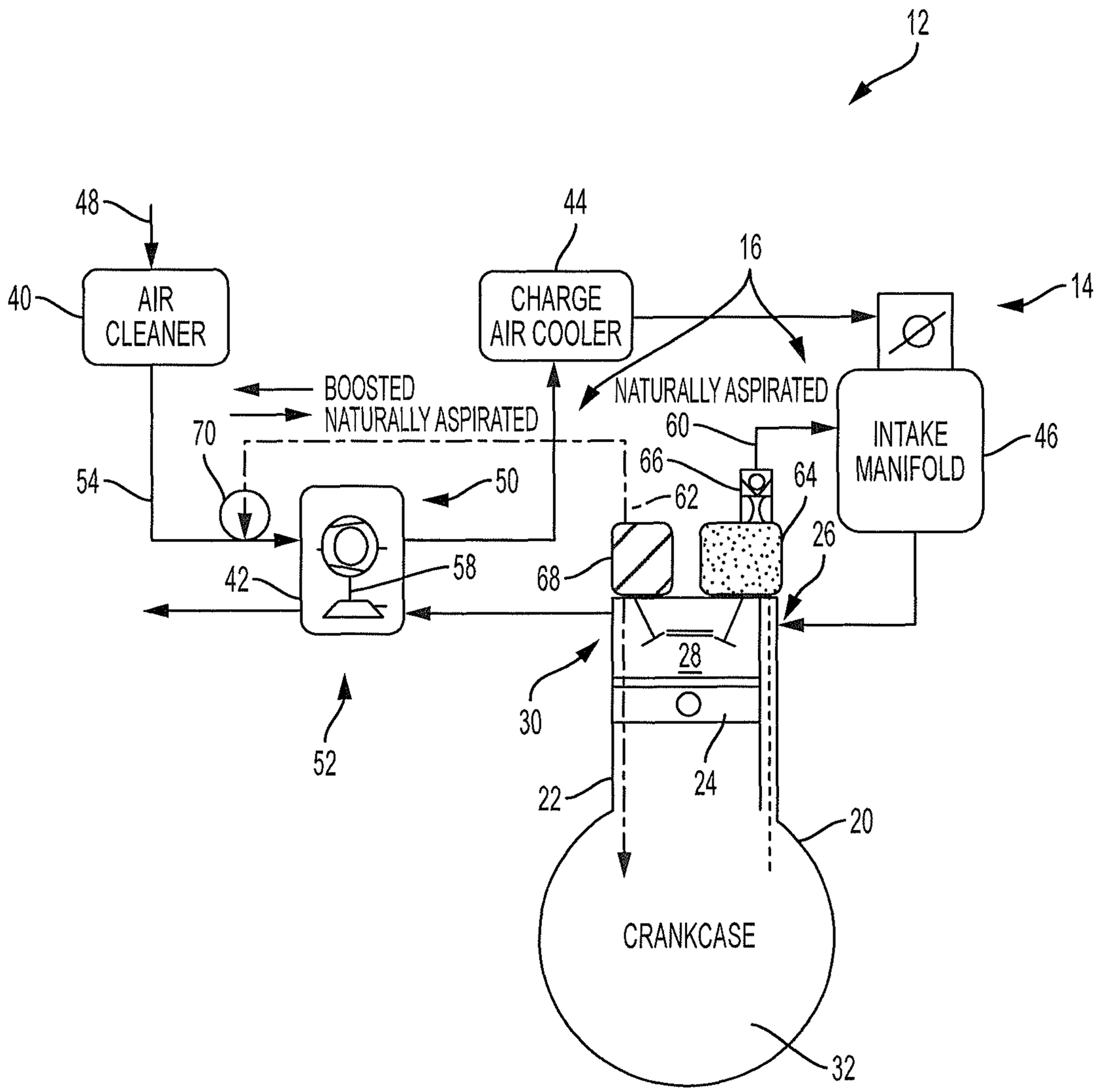

12
48
44
16
14
40
AIR CLEANER
CHARGE AIR COOLER
BOOSTED
NATURALLY ASPIRATED
NATURALLY ASPIRATED
70
60
INTAKE MANIFOLD
46
54
50
66
64
62
26
42
58
68
28
30
52
22
24
20
CRANKCASE
32

FIG. 1

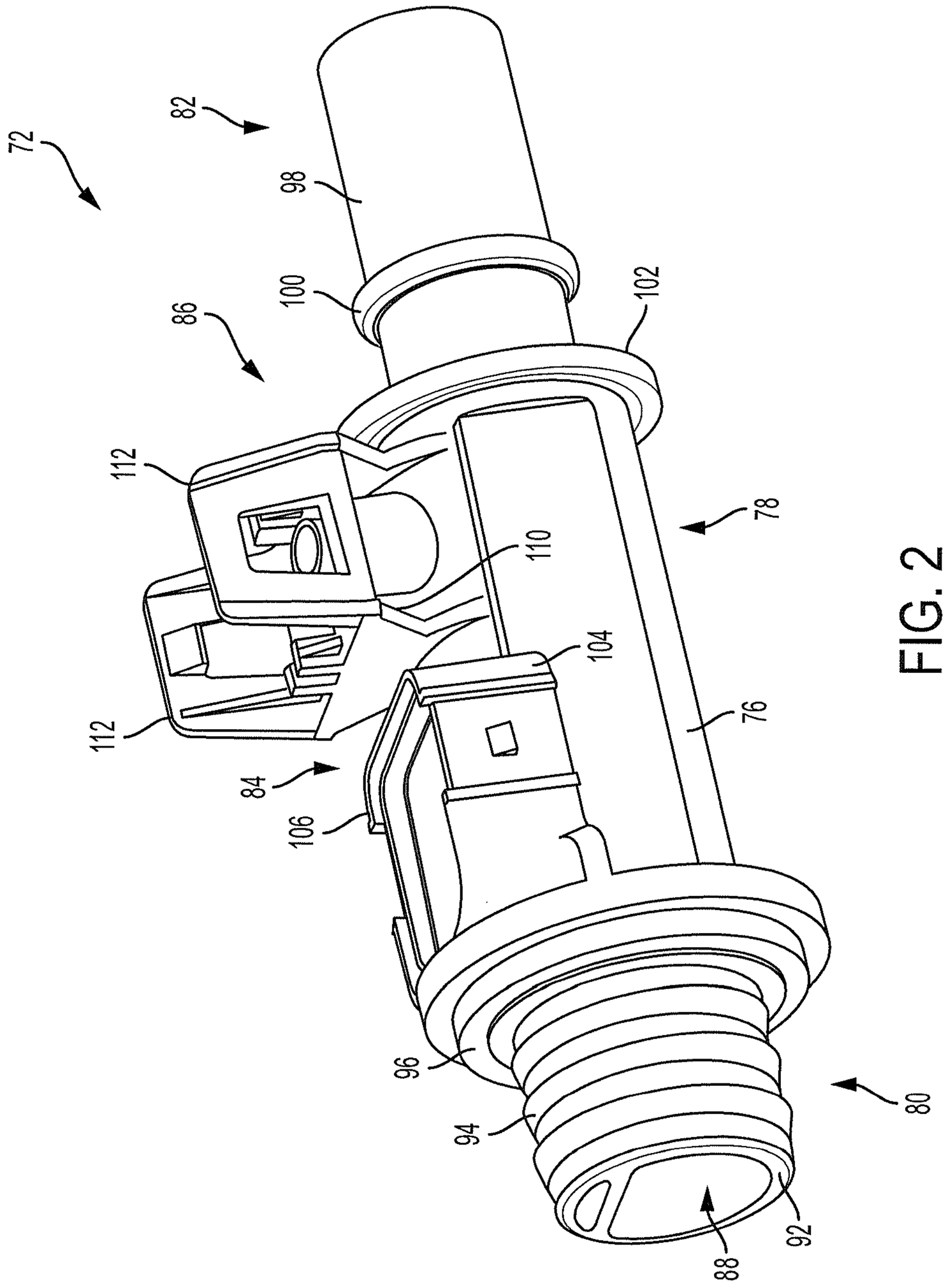


FIG. 2

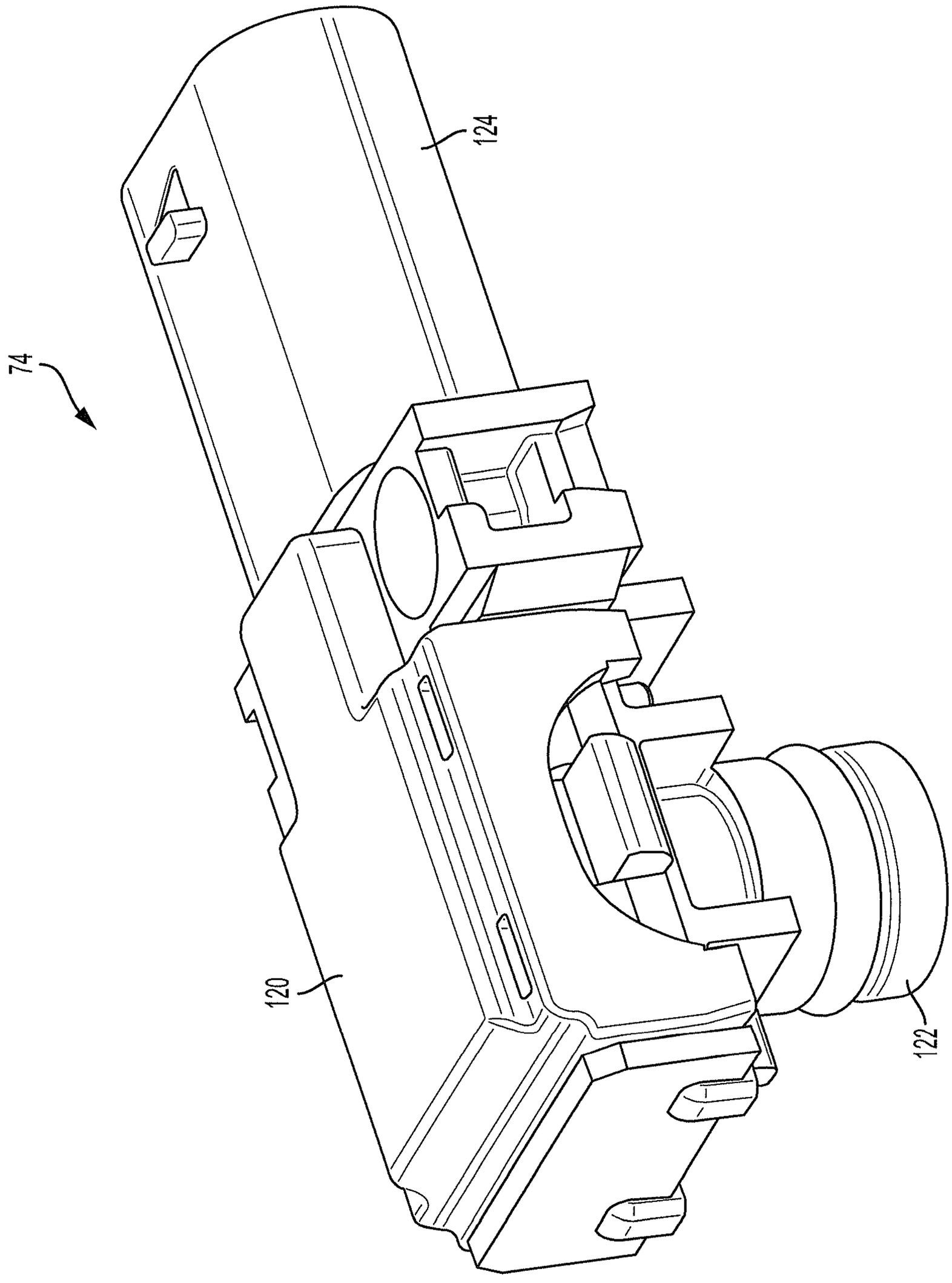


FIG. 3

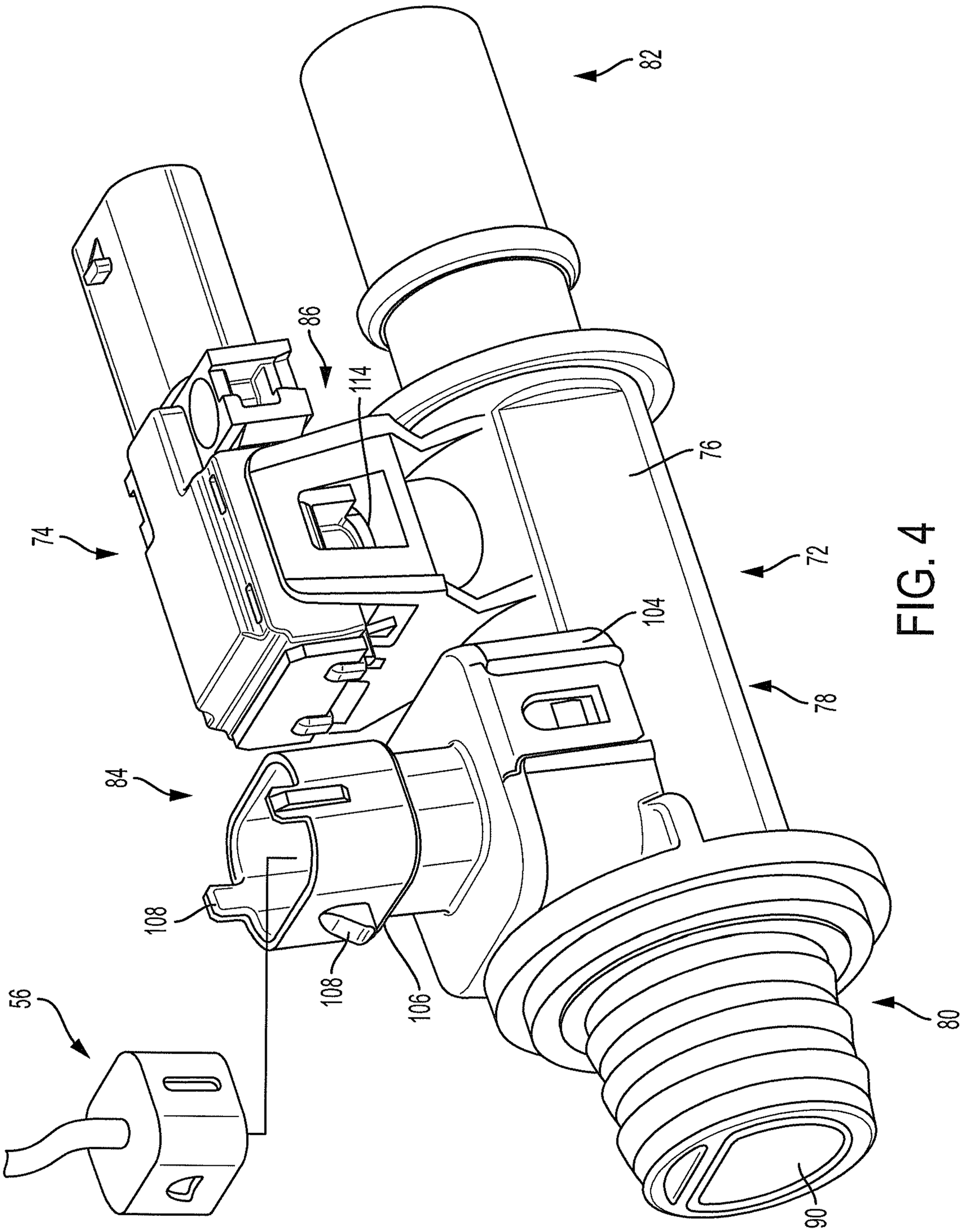


FIG. 4

INTEGRATED HEATER AND PRESSURE SENSOR FOR PCV SYSTEM

FIELD

The present application relates generally to positive crankcase ventilation (PCV) systems for internal combustion engines and, more particularly, to an integrated heater and pressure sensor for PCV systems.

BACKGROUND

Positive crankcase ventilation (PCV) systems are designed to evacuate blow-by gases from a crankcase of an internal combustion engine. These gases are formed of an air/fuel mixture that escapes the combustion chamber by "blowing by" the piston seals. To avoid corrosion and high pressures in the crankcase that can potentially damage the seals and increase pumping work, the blow-by gases must be vented therefrom. This is typically accomplished by returning the blow-by gases to the intake side of the internal combustion engine where the gases are mixed with the air/fuel mixture and subsequently burned. While current systems work well for their intended purpose, it is desirable to provide a simplified system with reduced cost and complexity.

SUMMARY

According to one example aspect of the invention, an integrated heater and pressure sensor assembly for a positive crankcase ventilation (PCV) system for a vehicle internal combustion engine is provided. The integrated assembly includes, in one exemplary implementation, a heater assembly configured to fluidly couple a PCV/makeup air (MUA) line and a vehicle air induction system line, the heater assembly configured to heat fluid passing into and out of the PCV/MUA line, and a pressure sensor assembly integrated directly into the heater assembly, the pressure sensor assembly configured to sense pressure pulsations in the PCV/MUA line.

In addition to the foregoing, the described integrated assembly may include one or more of the following features: wherein the pressure sensor assembly is removably coupled to the heater assembly; wherein the pressure sensor assembly is removably snap-fit to the heater assembly; wherein the heater assembly comprises a housing defining a passage therethrough, the passage configured to fluidly couple the PCV/MUA line and the air induction system line; and wherein the heater assembly housing comprises a main body portion, a clean side duct interface configured to couple to the air induction system line, and a PCV line interface configured to couple to the PCV/MUA line.

In addition to the foregoing, the described integrated assembly may include one or more of the following features: wherein the heater assembly housing comprises a heating element disposed within the passage: wherein the heater assembly housing further comprises an electrical connector electrically coupled to the heating element; wherein the heater assembly housing comprises a pressure sensor interface configured to receive the pressure sensor assembly; wherein the pressure sensor interface comprises a sensor support member, a plurality of retention clips extending outwardly from the sensor support member, and a sensor aperture configured to provide the pressure sensor assembly fluid communication with the housing passage; and wherein the pressure sensor assembly comprises a main sensor housing, a sensing tube configured to be inserted into the sensor aperture, and an electrical connector.

According to another example aspect of the invention, an internal combustion engine is provided. The engine includes, in one exemplary implementation, a crankcase; an air induction system having an air supply duct, a positive crankcase ventilation (PCV) system including a PCV/make-up air (MUA) line fluidly coupled between the crankcase and the air supply duct and configured to selectively vent blow-by gases from the crankcase and/or supply MUA to the crank case, and an integrated heater and pressure sensor assembly for the PCV system. The integrated heater and pressure sensor assembly includes a heater assembly fluidly coupled between the PCV/MUA line and the air supply duct, the heater assembly configured to heat fluid passing into and out of the PCV/MUA line, and a pressure sensor assembly integrated directly into the heater assembly, the pressure sensor assembly configured to sense pressure pulsations in the PCV/MUA line.

In addition to the foregoing, the described engine may include one or more of the following features: wherein the air induction system includes a turbocharger; wherein the integrated heater and pressure sensor assembly is fluidly coupled to the air supply duct upstream of the turbocharger; wherein integrated heater and pressure sensor assembly is welded directly to the air supply duct; wherein the pressure sensor assembly is removably coupled to the heater assembly; wherein the heater assembly comprises a housing defining a passage therethrough, the passage configured to fluidly couple the PCV/MUA line and the air induction system line; and wherein the heater assembly housing comprises a main body portion, a clean side duct interface configured to couple to the air supply duct; and a PCV line interface configured to couple to the PCV/MUA line, a heating element disposed within the passage, and a pressure sensor interface configured to receive the pressure sensor assembly.

In addition to the foregoing, the described engine may include one or more of the following features: wherein the pressure sensor interface comprises a sensor support member, a plurality of retention clips extending outwardly from the sensor support member, and a sensor aperture configured to provide the pressure sensor assembly fluid communication with the housing passage; and wherein the pressure sensor assembly comprises a main sensor housing, a sensing tube configured to be inserted into the sensor aperture, and an electrical connector.

Further areas of applicability of the teachings of the present disclosure will become apparent from the detailed description, claims and the drawings provided hereinafter, wherein like reference numerals refer to like features throughout the several views of the drawings. It should be understood that the detailed description, including disclosed embodiments and drawings references therein, are merely exemplary in nature intended for purposes of illustration only and are not intended to limit the scope of the present disclosure, its application or uses. Thus, variations that do not depart from the gist of the present disclosure are intended to be within the scope of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram of an example internal combustion engine having a PCV system, in accordance with the principles of the present disclosure;

FIG. **2** is a perspective view of a first portion of an example integrated PCV heater and pressure sensor that may

be utilized in the PCV system shown in FIG. **1**, in accordance with the principles of the present disclosure;

FIG. **3** is a perspective view of a second portion of the integrated PCV heater and pressure sensor that may be utilized in the PCV system shown in FIG. **1**, in accordance with the principles of the present disclosure; and

FIG. **4** is a perspective view of the integrated PCV heater and pressure sensor shown in FIGS. **2** and **3** after assembly, in accordance with the principles of the present disclosure.

DETAILED DESCRIPTION

The present application is directed to an integrated heater and pressure sensor for a positive crankcase ventilation (PCV) system of an internal combustion engine. Because of reversal of crankcase gases in a make-up air (MUA) line of the PCV system, the MUA line includes a heater to ensure oil in the blow-by gases does not freeze. Because the PCV/MUA systems fall under emissions regulation, a pressure sensor is included to detect crankcase pulsations and identify any disconnect in the system. Until now, the pressure sensor was located on a remote portion of the MUA line and included a remote mounted hose and many additional components such as clips, fasteners, brackets. The present disclosure provides an integrated PCV heater and pressure sensor that improves detection of MUA line disconnects, greatly reduces the number of system components, and simplifies assembly thereof.

Referring now to the drawings, FIG. **1** is a schematic illustration of an internal combustion engine **12** that generally includes a forced air induction system **14** and a PCV/MUA system **16**.

The engine **12** generally includes a cylinder block **20** defining one or more cylinders **22** to each receive a reciprocating piston **24** therein. An intake port **26** supplies an air/fuel mixture from the forced air induction system **14** to a combustion chamber **28** within the cylinder **22**. The air/fuel mixture is ignited in the combustion chamber **28** and the resulting exhaust gas is removed from the chamber via an exhaust port **30**. During the combustion, a portion of the exhaust gas can blow by the piston **24** into a crankcase **32** of the engine. As described herein in more detail, the PCV system **16** recirculates the blow-by gases back to the forced air induction system **14** for further combustion in the combustion chamber **28**.

The forced air induction system **14** generally includes an air cleaner **40**, a turbocharger **42**, a charge air cooler **44**, and an intake manifold **46**. Air enters the vehicle through an air intake **48** and is filtered in the air cleaner **40** before entering a compressor side **50** of the turbocharger **42**. The air is compressed and subsequently cooled in the charge air cooler **44** before being delivered to the intake port **26** via the intake manifold **46**. After combustion, the exhaust gas is removed from the combustion chamber **28** through exhaust port **30** before being directed to a turbine side **52** of the turbocharger **42**. The exhaust gas drives the turbine side **52**, which drives the turbocharger compressor side **50** via a shaft **58**, and the exhaust gas is subsequently supplied to a vehicle exhaust aftertreatment system (not shown).

In the example embodiment, the PCV/MUA system **16** generally includes a PCV line **60** and a PCV/MUA line **62**. The PCV line **60** is fluidly connected between the crankcase **32** and the intake manifold **46** to vent blow-by gases from the crankcase **32** to the intake manifold **46** under naturally aspirated conditions. PCV line **60** includes an oil separator **64** and a PCV valve **66**. The oil separator **64** is configured to remove oil from the blow-by gases as they are directed from the crankcase **32** to the intake manifold **46**, and PCV valve **66** is configured to regulate the flow of blow-by gases from the crankcase **32** to the intake manifold **46**. Additionally, PCV valve **66** is configured to limit flow from the intake manifold **46** back to the crankcase **32** under boost conditions. As such, this is an intended boost leak meant to limit the vacuum present in the crankcase **32** (driven by the PCV/MUA line **62**), which may increase pumping/frictional losses in the engine. The fresh air also flushes contaminants or debris just as the PCV/MUA line **62** provided under naturally aspirated conditions.

The PCV/MUA line **62** is fluidly connected between the crankcase **32** and a point of the forced air induction system **14** upstream of the turbocharger **42**. In boosted conditions, PCV/MUA line **62** vents the blow-by gases from the crankcase **32** to the clean side duct **54** or the air cleaner **40**. In un-boosted, naturally aspirated conditions, the PCV/MUA line **62** provides make-up air to the crankcase **32** to replace the blow-by gases vented through PCV line **60**. PCV/MUA line **62** includes an oil separator **68** configured to remove oil form the blow-by gases as they are directed from the crankcase **32** upstream of the turbocharger **42**. In the example embodiment, PCV/MUA line **62** further includes a combined or integrated heater and pressure sensor assembly **70**, as described herein in more detail.

With further reference to FIGS. **2-4**, in one example implementation, the PCV/MUA system **16** includes integrated heater and pressure sensor assembly **70**, which generally comprises a heater assembly **72** and a pressure sensor assembly **74**.

With reference to FIGS. **2** and **4**, the heater assembly **72** will be described in more detail. The heater assembly **72** is configured to heat air and/or blow-by gas supplied through PCV/MUA line **62** to prevent water or oil from freezing therein, which can damage the compressor wheel and/or obstruct flow in the forced air induction system **14** and/or the PCV/MUA system **16**. In the example embodiment, heater assembly **72** generally includes a housing **76** having a main body portion **78**, a clean side duct interface **80**, a PCV/MUA line interface **82**, an electrical connector **84**, and a pressure sensor interface **86**.

In the example embodiment, the housing **76** defines a port or passage **88** extending between interfaces **80**, **82**. Passage **88** is configured to direct intake air and blow-by gases between the PCV/MUA line **62** and a clean side duct **54** of the forced air induction system **14**. As such, passage **88** fluidly connects PCV/MUA line **62** and the clean side duct **54**.

A heating element **90** is disposed within passage **88** and is configured to electrically couple to an electrical connector **56**, which provides power to heat the heating element **90**. In the example embodiment, the heating element **90** is tubular and extends along at least a portion of an inner wall **92** defining the passage **88**. In some embodiments, the heating element **90** extends into the passage **88** formed in one or more of the clean side duct interface **80** and the PCV line interface **82**.

Clean side duct interface **80** is configured to couple to the clean side duct **54** and generally includes a tubular portion **94** and a stop surface **96** configured to receive a fitting of the clean side duct **54**. In the example embodiment, stop surface **96** is also configured as a weld interface and/or a retention wall for a clamp coupling. In some embodiments, the clean side duct interface **80** is clamped or welded to the clean side duct **54**. The PCV line interface **82** is configured to couple to the PCV/MUA line **62** and generally includes a tubular

portion **98**, a retention rib **100**, and an end surface **102** configured to receive a fitting or tube of the PCV/MUA line **62**.

In the example embodiment, electrical connector **84** is a female connector and extends outwardly from the main body portion **78**. The electrical connector **84** is configured to removably couple to the male electrical connector **56** to provide power to the heating element **90**. In the illustrated example, electrical connector **84** includes a base plate **104** and a hollow shell or fitting **106** extending outwardly therefrom. The hollow fitting **106** is configured to receive the electrical connector **56** therein and guide the electrical connector **56** into a position to establish an electrical connection between the electrical connector **56** and the heating element **90**. In the example implementation, the hollow fitting **106** includes one or more tabs or retention member **108** configured to removably engage the electrical connector and prevent unintended disconnection thereof. However, electrical connector **84** can have any suitable structure that enables electrical connector **84** to removably couple with electrical connector **56**.

In the example implementation, pressure sensor interface **86** generally includes a sensor support plate **110** and opposed retention clips **112**. The sensor support plate **110** is coupled to main body portion **78** and defines a sensor aperture **114** that enables insertion of at least a portion of the pressure sensor assembly **74** into the passage **88** to take pressure readings from the fluid flow therein. The opposed retention clips **112** extend outwardly from the sensor support plate **110** and are configured to releasably couple the pressure sensor assembly **74** to the heater assembly **72**. Although shown with opposed retention clips **112**, pressure sensor interface **86** can have various constructions, including fasteners, which enable the heater assembly **72** to removably couple with various pressure sensors.

With reference to FIGS. **3** and **4**, the pressure sensor assembly **74** will be described in more detail. The pressure sensor assembly **74** is configured to measure pressure pulsations of the blow-by gases as they travel through the PCV/MUA line **62** under boosted conditions to thereby detect if the PCV/MUA line **62** is disconnected from the clean side duct **54** of the forced air induction system **14**. The pressure sensor assembly **74** generally includes a main sensor housing **120**, a sensing tube **122**, and an electrical connector **124**. The main sensor housing **120** houses various pressure sensor components (not shown) configured to measure pressure in the PCV/MUA line **62**. The sensing tube **122** is configured to be inserted into the sensor aperture **114** in order to establish fluid communication between the pressure sensor components and the PCV/MUA line **62**. The electrical connector **124** is configured to couple to a connector (not shown) to provide electrical and/or signal communication with the vehicle. Accordingly, the pressure sensor assembly **74** is directly coupled to the heater assembly **72** to provide a simple and compact integrated PCV heater and pressure sensor assembly.

Described herein are systems and methods for a compact integrated PCV heater and pressure sensor assembly. The integrated assembly includes a pressure sensor assembly configured to releasably and directly couple to a heater assembly. This enables the pressure sensor assembly to quickly and easily snap-fit into the PCV heater, improve packaging, and reduce the number of components. Moreover, pressure sensor assembly is directly mounted to the heater assembly to detect pressure pulsations directly on the PCV/MUA line rather than from a remote mount that requires additional hose tubing for detection. As such, the integrated assembly reduces assembly time, cost, weight, packaging space, and number of components, as well as locates the pressure sensor assembly right at the hose connection to the air induction system to provide a more robust sensing position.

It should be understood that the mixing and matching of features, elements and/or functions between various examples may be expressly contemplated herein so that one skilled in the art would appreciate from the present teachings that features, elements and/or functions of one example may be incorporated into another example as appropriate, unless described otherwise above.

What is claimed is:

1. An integrated heater and pressure sensor assembly for a positive crankcase ventilation (PCV) system for a vehicle internal combustion engine, the integrated assembly comprising:

a heater assembly configured to fluidly couple a PCV/makeup air (MUA) line and a vehicle air induction system line, the heater assembly configured to heat fluid passing into and out of the PCV/MUA line; and

a pressure sensor assembly integrated directly into the heater assembly, the pressure sensor assembly configured to sense pressure pulsations in the PCV/MUA line.

2. The integrated assembly of claim **1**, wherein the pressure sensor assembly is removably coupled to the heater assembly.

3. The integrated assembly of claim **2**, wherein the pressure sensor assembly is removably snap-fit to the heater assembly.

4. The integrated assembly of claim **1**, wherein the heater assembly comprises a housing defining a passage therethrough, the passage configured to fluidly couple the PCV/MUA line and the air induction system line.

5. The integrated assembly of claim **4**, wherein the heater assembly housing comprises:

a main body portion;

a clean side duct interface configured to couple to the air induction system line; and

a PCV line interface configured to couple to the PCV/MUA line.

6. The integrated assembly of claim **4**, wherein the heater assembly housing comprises a heating element disposed within the passage.

7. The integrated assembly of claim **6**, wherein the heater assembly housing further comprises an electrical connector electrically coupled to the heating element.

8. The integrated assembly of claim **4**, wherein the heater assembly housing comprises a pressure sensor interface configured to receive the pressure sensor assembly.

9. The integrated assembly of claim **8**, wherein the pressure sensor interface comprises a sensor support member, a plurality of retention clips extending outwardly from the sensor support member, and a sensor aperture configured to provide the pressure sensor assembly fluid communication with the housing passage.

10. The integrated assembly of claim **9**, wherein the pressure sensor assembly comprises:

a main sensor housing;

a sensing tube configured to be inserted into the sensor aperture; and

an electrical connector.

11. An internal combustion engine comprising:

a crankcase;

an air induction system having an air supply duct;

a positive crankcase ventilation (PCV) system including a PCV/make-up air (MUA) line fluidly coupled between

the crankcase and the air supply duct and configured to selectively vent blow-by gases from the crankcase and/or supply MUA to the crankcase; and

an integrated heater and pressure sensor assembly for the PCV system, comprising:

a heater assembly fluidly coupled between the PCV/MUA line and the air supply duct, the heater assembly configured to heat fluid passing into and out of the PCV/MUA line; and

a pressure sensor assembly integrated directly into the heater assembly, the pressure sensor assembly configured to sense pressure pulsations in the PCV/MUA line.

12. The engine of claim **11**, wherein the air induction system includes a turbocharger.

13. The engine of claim **12**, wherein the integrated heater and pressure sensor assembly is fluidly coupled to the air supply duct upstream of the turbocharger.

14. The engine of claim **13**, wherein integrated heater and pressure sensor assembly is welded directly to the air supply duct.

15. The engine of claim **11**, wherein the pressure sensor assembly is removably coupled to the heater assembly.

16. The engine of claim **11**, wherein the heater assembly comprises a housing defining a passage therethrough, the passage configured to fluidly couple the PCV/MUA line and the air induction system line.

17. The engine of claim **16**, wherein the heater assembly housing comprises:

a main body portion;

a clean side duct interface configured to couple to the air supply duct; and

a PCV line interface configured to couple to the PCV/MUA line;

a heating element disposed within the passage; and

a pressure sensor interface configured to receive the pressure sensor assembly.

18. The engine of claim **17**, wherein the pressure sensor interface comprises a sensor support member, a plurality of retention clips extending outwardly from the sensor support member, and a sensor aperture configured to provide the pressure sensor assembly fluid communication with the housing passage.

19. The engine of claim **18**, wherein the pressure sensor assembly comprises:

a main sensor housing;

a sensing tube configured to be inserted into the sensor aperture; and

an electrical connector.

* * * * *